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LISTS OF SPECIES

Species of Harpacticoida (Crustacea, Copepoda) from the phytal of Porto de Galinhas coral reefs, northeastern Brazil

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ABSTRACT: The coral reefs of Porto de Galinhas Beach (Pernambuco, Brazil, Northeast region) are among the most important tourist destinations in the country. However, this ecosystem is being increasingly threatened by impacts related to tourism. A first list of the Harpacticoida species found in the phytal of these reefs is provided here. The total of 1501 individuals analyzed included 42 species belonging to 13 families and 32 genera. The dominant species were *Parastenhelia spinosa*, *Amphiascoides* sp., *Robertsonia knoxi*, *Ameira parvula*, *Paralaophonte congenera congenera* and *Amphiascopsis cinctus*. First records for the Brazilian coast include the subspecies *Nitocra affinis californica* and nine species: *Nannomesochra arupinensis*, *Cletodes* aff. *pseudodissimilisoris*, *Esola lobata*, *Paralaophonte congenera* (*sensu* Yeatman 1962), *Sarsamphiascus parvus* (*sensu* Rouch 1962), *Rhyncholagena littoralis*, *Stenhelia gibba*, *Alteutha roeae* and *Xouthous purpurocinctus*. The high diversity and the isocommunity hypothesis are discussed.

INTRODUCTION

The Brazilian coral reefs form unique structures that differ significantly from other well-known coral reefs in the world, in their low-diversity coral fauna which is rich in endemic species; the presence of a relict fauna from the Tertiary, which forms unusual mushroom-shaped coral pinnacles; the important role of encrusting coralline algae in the construction of the reef structure; and the nearshore bank reefs that may be surrounded by and even filled with muddy siliciclastic sediments. These reefs are among the most conspicuous marine ecosystems of tropical Brazil, and include the southernmost coral-reef communities in the Atlantic Ocean (Maida and Ferreira 1997; Leão and Dominguez 2000).

The coral reefs of Porto de Galinhas Beach in the state of Pernambuco, northeast Brazil are one of the most important tourist destinations in the country. These formations have a total area of 0.42 km^2 and are located very near the coast. Due to the ease of access, large numbers of tourists are taken daily by rafts and are allowed to disembark and walk across reef formations during tides below 0.4 m when the reef is exposed (Alcantara *et al.* 2004). The same reef also contains areas that have been permanently conserved since 2004 (between 2004 and 2009, 70% of the total reef area was protected). These areas are marked by buoys and ropes, and tourists are forbidden to enter. Of the reef areas that are both exposed during low tides and easy to access, this is the only protected area along the coast of Pernambuco.

On the reef flat, the hard substrate is dominated by zoanthids and thick turf-forming macroalgae (Maida and Ferreira 1997). Macroalgae are among the major contributors to reef primary production, and provide shelter to an extremely abundant meiofauna assemblage (Gibbons and Griffiths 1986).

Harpacticoida is one of nine orders of the subclass Copepoda. Harpacticoids are small crustaceans (ranging from 0.2 to 2.5 mm in length), and among Copepoda, they are the most quantitatively important order in marine benthic ecosystems. This order comprises nearly 6,000 species in 645 genera and 59 families (Wells 2007; Giere 2009; Ahyong *et al.* 2011). However, data from well-studied shallow coastal areas (Veit-Koehler *et al.* 2010) can include proportions of unidentified species as high as 54%. Moreover, deep-sea expeditions have reported a mean of 97% unknown species (George and Schminke 2002; Seifried 2004). Extrapolating from these proportions indicates that more than 21,000 additional unrecorded species exist.

In phytal environments, Harpacticoida is regularly the dominant meiofauna taxon (Hicks 1977; Coull *et al.* 1983; Hall and Bell 1993) and shows high diversity (Hicks 1985; Sarmento *et al.* 2012). Harpacticoids have high fatty-acid contents, derived from their preferred diatom food, and play a decisive nutritional role for small fish, carnivorous crustaceans (shrimp and their larvae), and polychaetes (Coull 1999; Giere 2009). Thus, these metazoans are a key component of the benthic ecosystem, contributing significantly to energy transfer to higher trophic levels (Coull 1988; Danovaro *et al.* 2007).

This report lists the species of Harpacticoida inhabiting the phytal environment of reef formations at Porto de Galinhas Beach in Pernambuco. This information provides a basis to improve knowledge of the local biodiversity, which is increasingly threatened by tourism.

MATERIALS AND METHODS

Samples were collected in February, October, November and December 2009 on the reefs of Porto de Galinhas Beach, located at 08°30'26" to 08°30'39" S, and 34°59'52" to 34°59'55" W (Figure 1). In total, 57 sampling sites were randomly selected across the reef flat. Samples were taken

using a corer to delimit a 10 cm^2 area. The turfs were collected by cutting the algal turf down to the reef surface using a metal scraper, to ensure that all turf and underlying sediment were removed. Meiofauna samples were preserved in 4% formalin in seawater in the field. In the laboratory, meiofauna was extracted from turfs by manual elutriation with filtered water, through geological sieves with mesh sizes of 0.5 and 0.063 mm. Under a Leica EZ4 stereomicroscope, the first 25 individuals of harpacticoid copepods were selected from each replicate and placed in Eppendorf tubes with 70% ethanol. The harpacticoids were identified under an optical microscope (Leica DM 2500) following the taxonomic keys of Lang (1948; 1965), Huys *et al.* (1996) and Wells (2007), as well as original species descriptions. Specimens have been deposited in the Coleção de Carcinologia of the Museu de Oceanografia Petrônio Alves Coelho at the Universidade Federal de Pernambuco (MOUFPE). The Shannon-Wiener (H', using log_2), Pielou's evenness (J') and Species Richness indices were calculated using the software Primer® v.6 (Plymouth Routines in Multivariate Ecological Researches).

Results and Discussion

A total of 1501 individuals of harpacticoid copepods were analyzed, and 42 species, belonging to 13 families and 32 genera, were recorded for the phytal of Porto de Galinhas reefs (Table 1). This checklist adopts the nomenclatural modifications proposed by Huys (2009). Species of the families Ectinosomatidae, Harpacticidae, Normanellidae and Tisbidae were not identified, because of a small number of individuals found (*e.g.*, *Normanella* and *Tisbe*) or due to the urgent need for revisions of certain genera (*e.g.*, *Ectinosoma* and *Harpacticus*).

The dominant families in the study area were Miraciidae (with 38.13% of total individuals), Parastenheliidae (15.55%) and Laophontidae (10%). Miraciidae had the highest number of species (13), followed by Laophontidae (9), Ameiridae (4) and Canthocamptidae (3). The other families had only one or two species.

The dominant species were *Parastenhelia spinosa* (15.55%), *Amphiascoides* sp. (8.6%), *Robertsonia knoxi* (7.76%), *Ameira parvula* (6.52%), *Paralaophonte congenera congenera* (5.44%) and *Amphiascopsis cinctus* (5.13%), which together accounted for about 49% of the total of individuals.

A review of the literature about Brazilian harpacticoids (Reid 1998; Wandeness *et al.* 1998; Sarmento and Santos 2012; Sarmento *et al.* 2012) shows that the subspecies *Nitocra affinis californica* and the following nine species are recorded for the first time along the Brazilian coast: *Nannomesochra arupinensis*, *Cletodes* aff. *pseudodissimilisoris*, *Esola lobata*, *Paralaophonte congenera* (*sensu* Yeatman 1962), *Sarsamphiascus parvus* (*sensu* Rouch 1962), *Rhyncholagena littoralis*, *Stenhelia gibba*, *Alteutha roeae* and *Xouthous purpurocinctus*. Members of the genera *Nitocra* and *Stenhelia* are recorded for the first time for the phytal of Porto de Galinhas reef.

The assemblage of Copepoda Harpacticoida found in the phytal of Porto de Galinhas had high levels of species richness (total 42 species), evenness (overall J´= 0.81) and diversity (overall H´(log_2)= 4.52 bits). This level of diversity is higher than most diversity values reported for other phytal environments, as well as most of those for sediments in other coastal environments (Sarmento *et al.* 2012). However, the diversity calculated for the phytal of Porto de Galinhas was very similar to the values reported by Sarmento *et al.* (2012) in the phytal of Arraial do Cabo rocky shores in Rio de Janeiro, Brazil.

Areas covered by different species of algae, which are associated with large amounts of filamentous epiphytes, have much greater spatial heterogeneity compared to more homogeneous or monospecific areas (Hicks 1985). Environmental complexity implies that the different microhabitats will favor the establishment of animals with different habits and/or morphological adaptations. Consequently, this allows the coexistence of different species, foraging different niches in the phytal and decreasing competitive interactions, with the consequent establishment of a diverse harpacticoid fauna (Hicks 1977; Arroyo et al. 2006).

In the present study, the turfs covering Porto de Galinhas reefs were formed mainly by two species of algae: *Chondrophycus papillosus* (Agardh) Garbary and Harper and *Gelidiella acerosa* (Forsskål) Feldmann and Hamel (Figure 2). These algae have a thallus with several tufted, entangled, cylindrical, stiff to cartilaginous branches. It is apparent that these algae together with epiphytes and the attached sediment provide a suitable habitat for the highly diverse harpacticoid assemblage found in Porto de Galinhas.

In a previous study, Sarmento *et al.* (2012) discussed the concept of isocommunities in the phytal environment. This concept suggests that similar substrates, although geographically separated, are inhabited or colonized by the same set of dominant genera, although the species composition may vary between sites (Por 1964). Arraial do Cabo and Porto de Galinhas are located along the same coast, but certain significant differences between these sites and studies can be noted. In addition to their separation by nearly 2,300 km, the algal composition is very different. Furthermore, in Arraial do Cabo, the sea water has a mean temperature of 20°C and the samples were taken in the subtidal on rocky shores. On the other hand, in Porto de Galinhas the mean water temperature

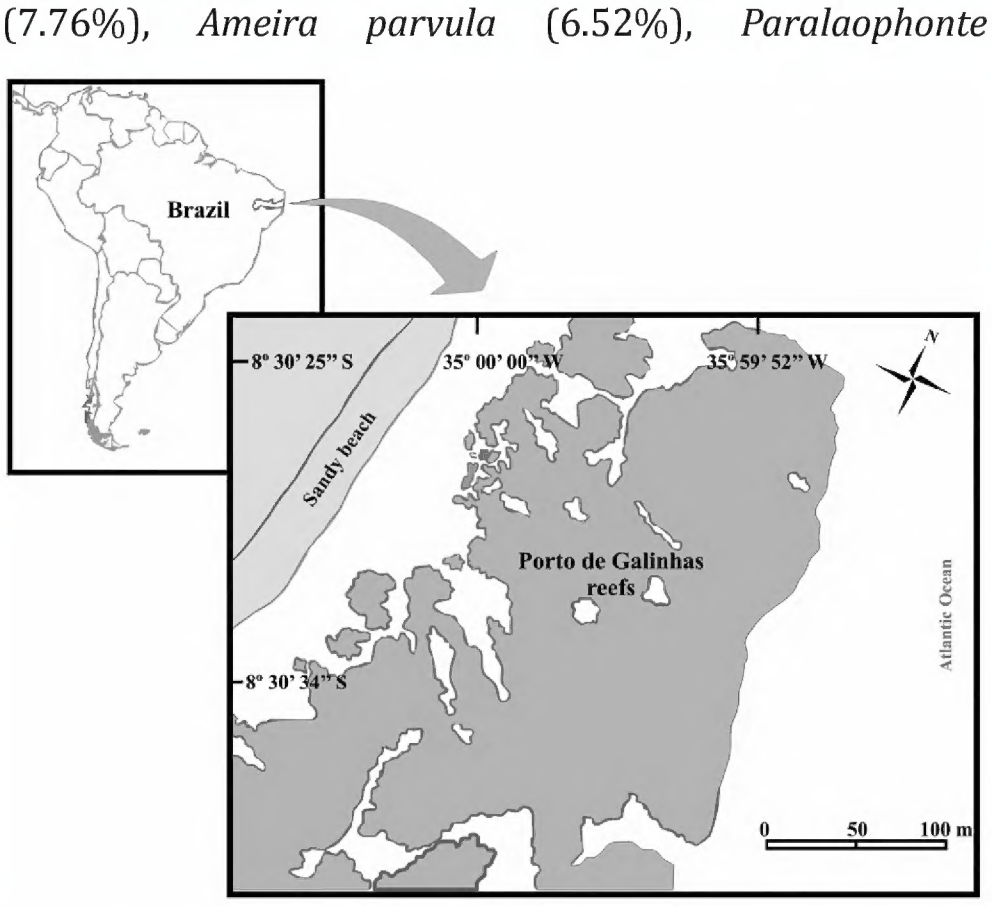

Figure 1. Study area on the reef formation located at Porto de Galinhas Beach, state of Pernambuco, northeastern Brazil.

is around 27°C and samples were taken in the intertidal of coral reefs. Despite these differences, in the phytal of Porto de Galinhas about 65% of the recorded genera were the same as those found by Sarmento *et al.* (2012) in the phytal of Arraial do Cabo. Thus, this similarity in genus composition reinforces the hypothesis of geographical parallelism or isocommunities for phytal environments.

Differently from other crustacean inventories, in the present study, many (35.7%) of the animals collected belong to undescribed species. However, this is a very common result for Harpacticoida. The state of knowledge of the taxonomy of these animals varies enormously among geographic regions. The harpacticoid fauna of certain regions (such as the North Sea in Europe) has been well studied and described since the 19th century (for literature see Wells 2007 and Huys 2009). On the other hand, despite the great extent of the Brazilian coast, taxonomic studies of Harpacticoida are few and have resumed only recently (*e.g.,* Kihara and Rocha 2007; Vasconcelos *et al.* 2008; 2009; Wandeness *et al.* 2009), after some earlier descriptions during the 1950s, mainly by Hans Jakobi (some of these species are now considered *species inquirendis*).

The harpacticoid copepod fauna in the phytal of Porto de Galinhas is highly diverse. A recent study has demonstrated the importance of these organisms as potential bioindicators of human disturbance in sensitive areas such as coral reefs (Sarmento and Santos 2012). Therefore, studies on the biodiversity of these animals in coral reefs and other environments need to be encouraged, especially in regions where taxonomic knowledge is inadequate, such as the Brazilian coast.

Table 1. List of Harpacticoida species found in the phytal environment of Porto de Galinhas reef (Pernambuco, northeastern Brazil).

Order Harpacticoida Sars 1903		Voucher
Family	**Species**	
Family Ameiridae Boeck 1865	*Ameira parvula* (Claus, 1866)	MOUFPE14961
	Nitocra affinis californica Lang, 1965	MOUFPE14962
	Psyllocamptus (Psyllocamptus) sp.1	MOUFPE14963
	Psyllocamptus (Psyllocamptus) sp.2	MOUFPE14964
Family Canthocamptidae Brady 1880	*Mesochra pygmaea* (Claus, 1863)	MOUFPE14965
	Mesochra sp.	MOUFPE14966
	Nannomesochra arupinensis (Brian, 1925)	MOUFPE14967
Family Cletodidae T. Scott 1905	*Cletodes* aff. *pseudodissimilisoris* Gómez, 2000	MOUFPE14968
	Cletodes sp.	MOUFPE14969
Family Dactylopusiidae Lang 1936	*Dactylopusia tisboides* (Claus, 1863)	MOUFPE14970
	Paradactylopodia brevicornis (Claus, 1866)	MOUFPE14971
Family Laophontidae T. Scott 1905	*Esola lobata* Huys and Lee, 2000	MOUFPE14972
	Esola vervoorti Huys and Lee, 2000	MOUFPE14973
	Heterolaophonte campbelliensis (Lang, 1934)	MOUFPE14974
	Laophonte cornuta Philippi, 1840	MOUFPE14975
	Laophonte parvula Sars, 1908	MOUFPE14976
	Loureirophonte sp.	MOUFPE14977
	Paralaophonte brevirostris (Claus, 1863)	MOUFPE14978
	Paralaophonte congenera congenera (Sars, 1908)	MOUFPE14979
	Paralaophonte congenera (Sars, 1908) [*sensu* Yeatman 1962]	MOUFPE14980
Family Longipediidae Boeck 1865	*Longipedia* sp.	MOUFPE14981
Family Louriniidae Monard 1927	*Lourinia armata* (Claus, 1866)	MOUFPE14982
Family Metidae Boeck 1873	*Laubieria* sp.	MOUFPE14983
	Metis holothuriae (Edwards, 1891) [*sensu* Vervoort 1964]	MOUFPE14984
Family Miraciidae Dana 1846	*Amonardia* sp.	MOUFPE14985
	Amphiascoides sp.	MOUFPE14986
	Amphiascopsis cinctus (Claus, 1866)	MOUFPE14987
	Diosaccus sp.	MOUFPE14989
	Melima sp.1	MOUFPE14990
	Melima sp.2	MOUFPE14991
	Paramphiascella robinsoni (A. Scott, 1902) [*sensu* Gurney 1927]	MOUFPE14992
	Rhyncholagena littoralis Por, 1967	MOUFPE14993
	Robertsonia knoxi (Thompson and A. Scott, 1903)	MOUFPE14994
	Robertsonia mourei Nogueira, 1961	MOUFPE14995
	Sarsamphiascus parvus Sars, 1906 [*sensu* Rouch 1962]	MOUFPE14988
	Stenhelia gibba Boeck, 1865	MOUFPE14996
	Typhlamphiascus sp.	MOUFPE14997
Family Orthopsyllidae Huys 1990	*Orthopsyllus* sp.1	MOUFPE14998
	Orthopsyllus sp.2	MOUFPE14999
Family Parastenheliidae Lang 1936	*Parastenhelia spinosa* (Fischer, 1860)	MOUFPE15000
Family Peltidiidae Claus 1860	*Alteutha roeae* Hicks, 1982	MOUFPE15001
Family Pseudotachidiidae Lang 1936	*Xouthous purpurocinctus* (Norman and T. Scott, 1905)	MOUFPE15002

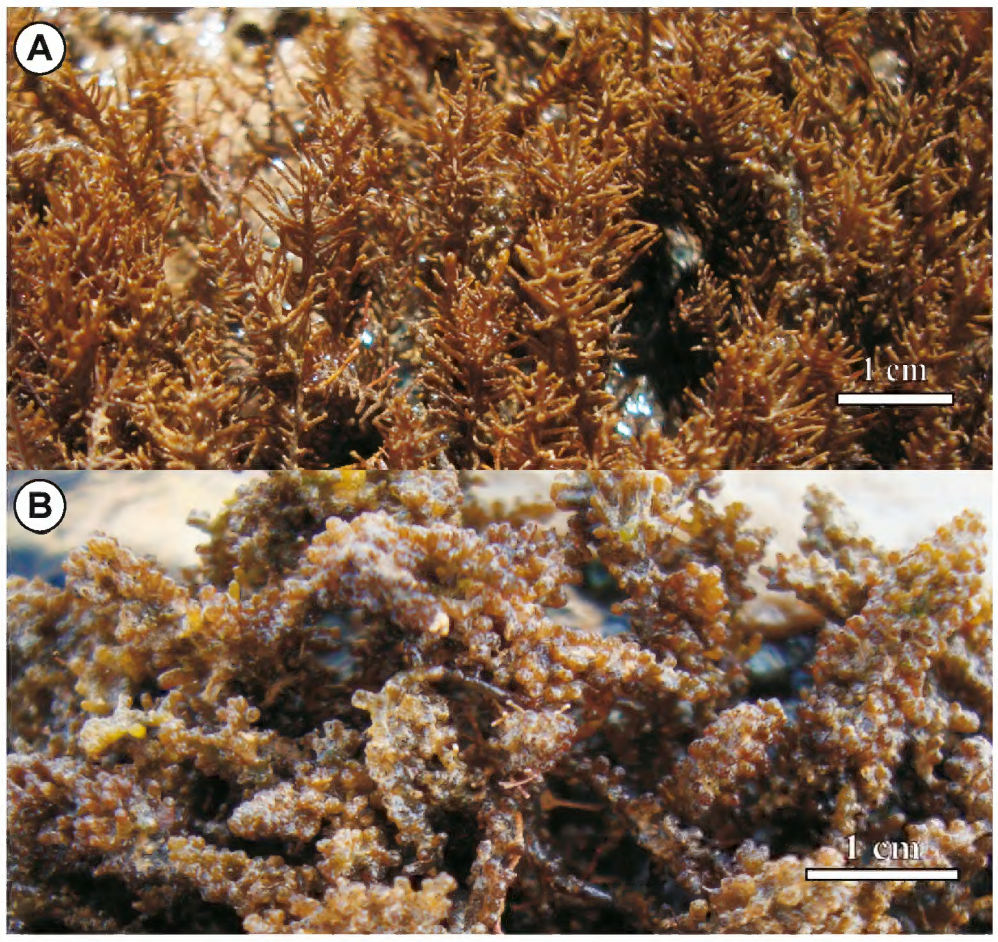

Figure 2. Two main species of algae covering the reefs at Porto de Galinhas in northeastern Brazil. a) *Gelidiella acerosa* and b) *Chondrophycus papillosus*.

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